PHASE 3 RENEWABLES

BIOGAS TO BIOMETHANE

A PROVEN OPTION FOR ON-FARM ENERGY PRODUCTION

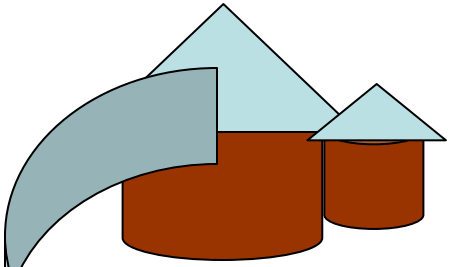
Norma McDonald * Sean Mezei

QuestAir

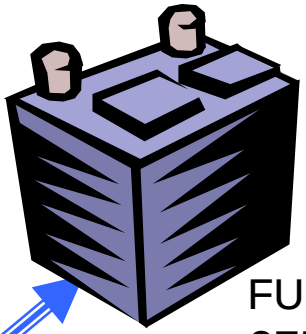
Vast Natural Resources

OPTIONS FOR USE OF BIOGAS

BIOGAS

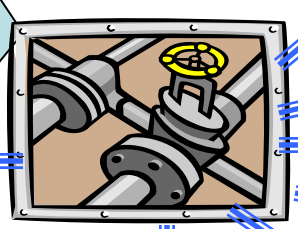


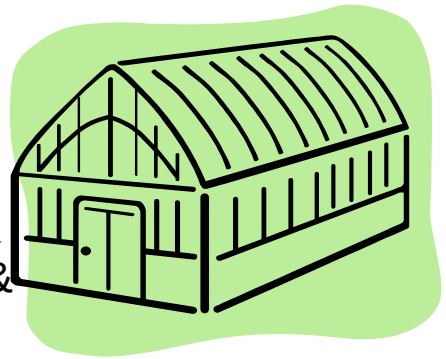
DIGESTER TANKS



FUEL CELLS

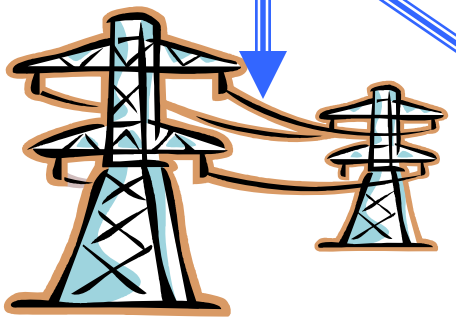
Wheeling power to local businesses



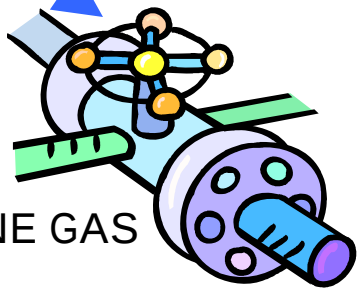


Greenhouse Heat & Power

FLARE



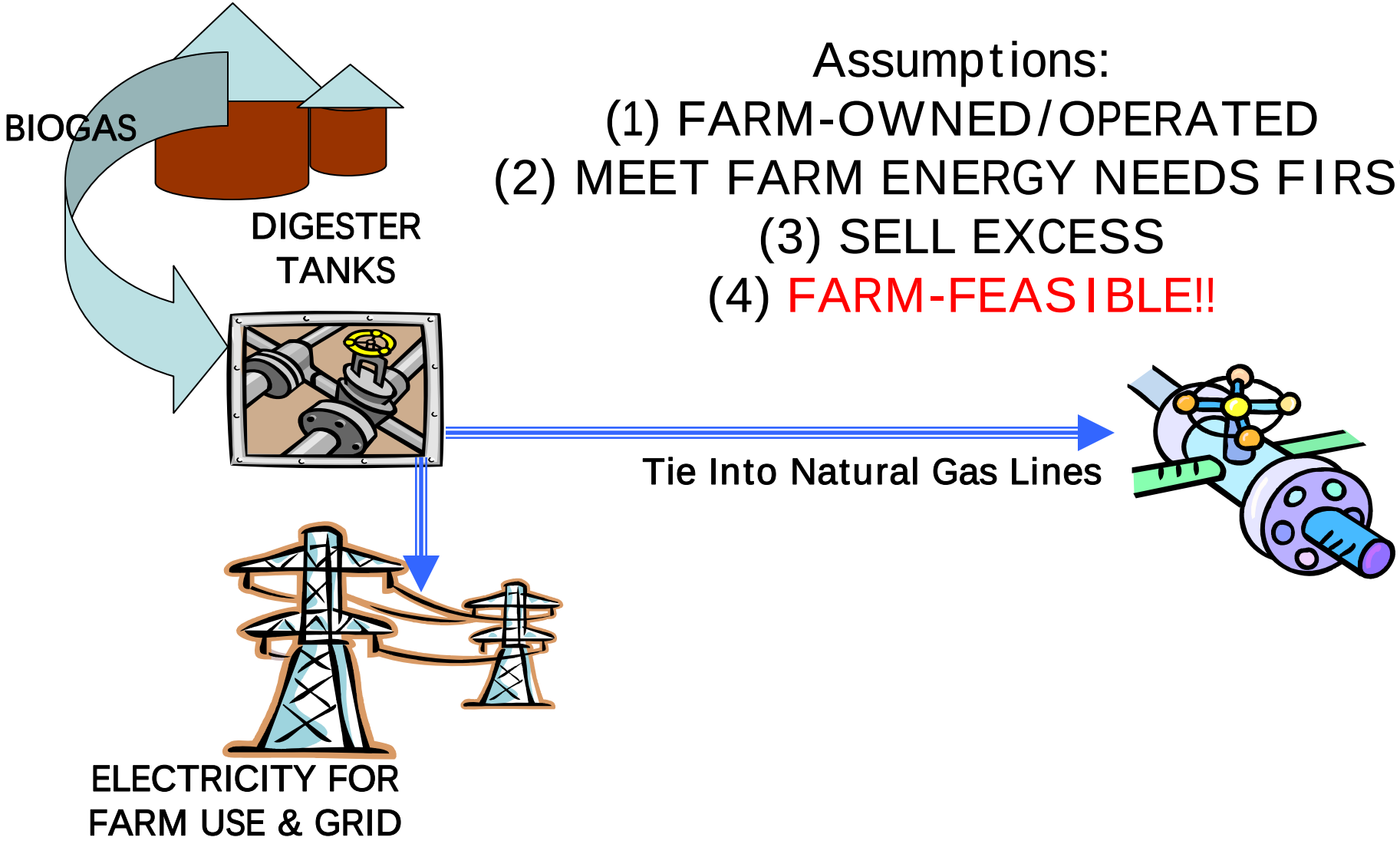
ELECTRICITY FOR FARM USE & GRID



PIPELINE GAS

CBM/LBM

TODAY'S COMPARISON – ELECTRICITY OR NATURAL GAS?



Assumptions:
(1) FARM-OWNED/OPERATED
(2) MEET FARM ENERGY NEEDS FIRST
(3) SELL EXCESS
(4) FARM-FEASIBLE!!

"SOFT-SIDE" CONSIDERATIONS

- Bargaining power of the utilities – forced by PURPA, or voluntary?
- Receptivity to new sources of supply
- Electric RPS or Renewable Energy RPS
- Demand variability
- Price volatility
- Shades of "Green" – type of fossil fuel replaced
- Type of Contract – fixed or minimum quantity?

Electrical Interconnection Cost & Feasibility Determination

-Existing peak load

-Proximity to site

-Type of Recloser(s) at substation and sectionalizing devices

-Service Voltage Compatibility

-Ownership of switchgear

-Number & type of isolating transformers

-Communication & metering requirements

Cost & Feasibility Determination

Transmission Line

Distribution Line

Local or On-Site Use

-Gas Specifications:

BTU value, H_2S, CO_2, N_2, O_2, H_2O and

Pressure of Insertion or Use

These requirements will drive economic and technical feasibility.

- Proximity to site
- Odorization
- Monitoring and Metering Requirements

PROCESS OVERVIEW - ELECTRICITY

FEEDSTOCK SOURCE

PIPING & PUMPING

DIGESTION TANKS AND GAS STORAGE

CONDENSATE TRAPS

H2S REMOVAL

GENERATOR

CONTROLS

PCC

WASTE HEAT USAGE ?

DIGESTER HEATING

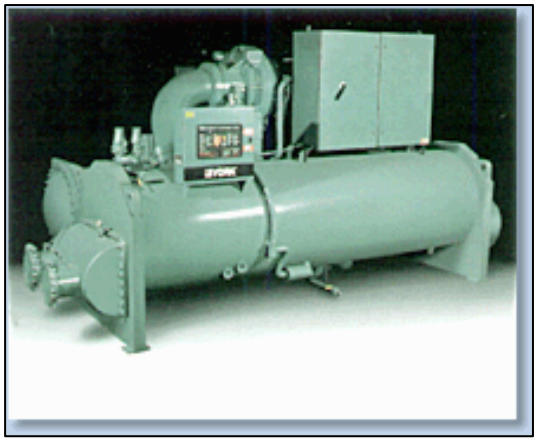
BIOFIBER DRYING

PROCESS OVERVIEW – UPGRADED GAS

FEEDSTOCK SOURCE

PIPING & PUMPING

DIGESTION TANKS AND GAS STORAGE



GREATER MOISTURE REMOVAL REQUIREMENTS

GREATER H2S REMOVAL REQUIREMENTS

Technology Option : Water Scrubbing

Process Summary

- Use pressurized water to absorb compressed CO2 from the biogas

Advantages:

- Simple
- Mature technology

Disadvantages:

- Uneconomical in most cases, due to:
  - High water demand
  - Large footprint required
  - Corrosion issues
  - Tight natural gas specifications may require post treatment
  - Methane emissions to atmosphere

Technology Option : Membrane Separation

Process Summary

- Use a membrane system to remove CO2 from the biogas

Advantages:

- Primary treatment relatively low cost

Disadvantages:

- High feed pressure required
- High cost gas pretreatment needed, or membrane quickly contaminates and fails
- Membranes must be replaced periodically under normal operation

Technology Option : Physical Absorption

Process Summary

- Use a working fluid (e.g. amine) to selectively adsorb the CO2 from biogas

Advantages:

- High methane yield

Disadvantages:

- Does not economically scale down to typical biogas flows and CO2 content
- Operating costs are high due to:
  - Relatively complex process
  - Normally high parasitic energy load to regenerate solution
  - Working fluid replacement costs
  - Variable costs due to pumps and associated process equipment

Technology Option : Conventional PSA

Process Summary

- Use a regenerable media to selectively remove CO2 from the biogas

Advantages:

- Some tolerance of contaminants

Disadvantages:

- Higher capital costs
- Control complexity
- Lower CH4 yield than physical absorption
- No supplier found for farm-scale project

Technology Option : Rapid Cycle PSA

Process Summary

- Use a conventional PSA process at 5 to 20 times the cycle speed

Advantages:

- Lower capital costs
- Tolerant to impurities
- Simple operator interface

Disadvantages:

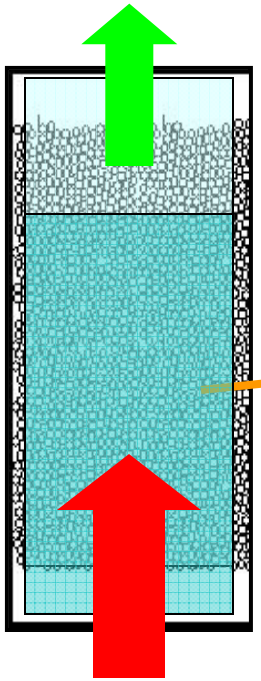
- Lower CH4 yield than physical absorption

HOW THE BIOGAS IS PROCESSED USING PSA

Least adsorbed gas component flows through bed as pure product gas

(high purity CH_4, some O_2, N_2)

Production Step

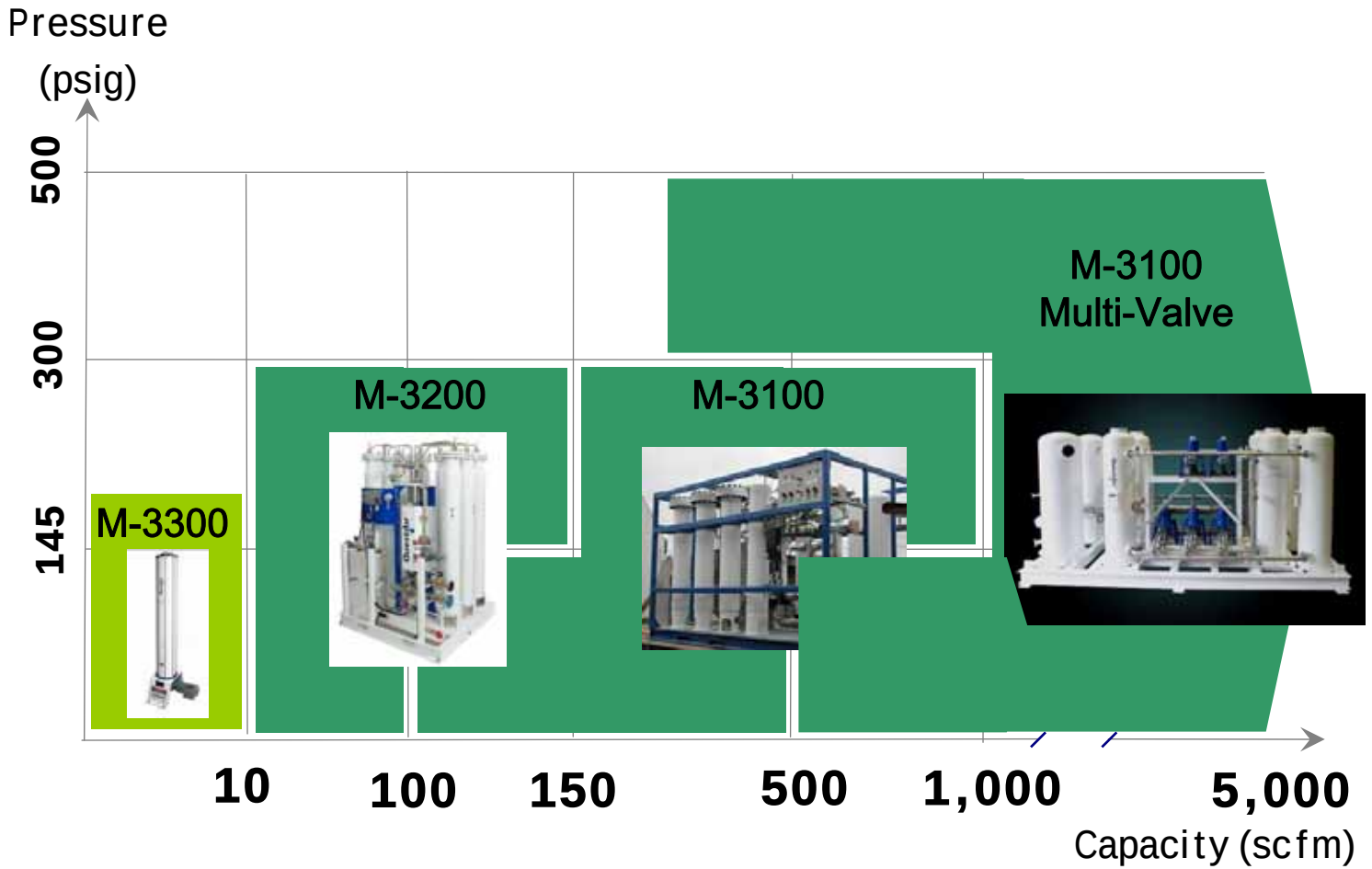


Adsorbent Bed

Rotary valve opens and unprocessed raw feed gas flows into adsorbent bed at high pressure

(eg. CH_4,CO_2,O_2,N_2)

Product Range – Biogas Upgrading



How we assessed the options

Technology	Water Scrubber	Membrane	Physical Absorption	Conventional PSA	QuestAir PSA
Proven in Biogas	+	-	-	+	+
Low Capital Cost	-	+	-	-	+
Low Operating Cost	-	-	-	+	+
Low CH4 Emissions	-	+	+	+	+
Simplicity	-	+	-	-	+

PROCESS OVERVIEW – NATURAL GAS cont'd

COMPRESSION

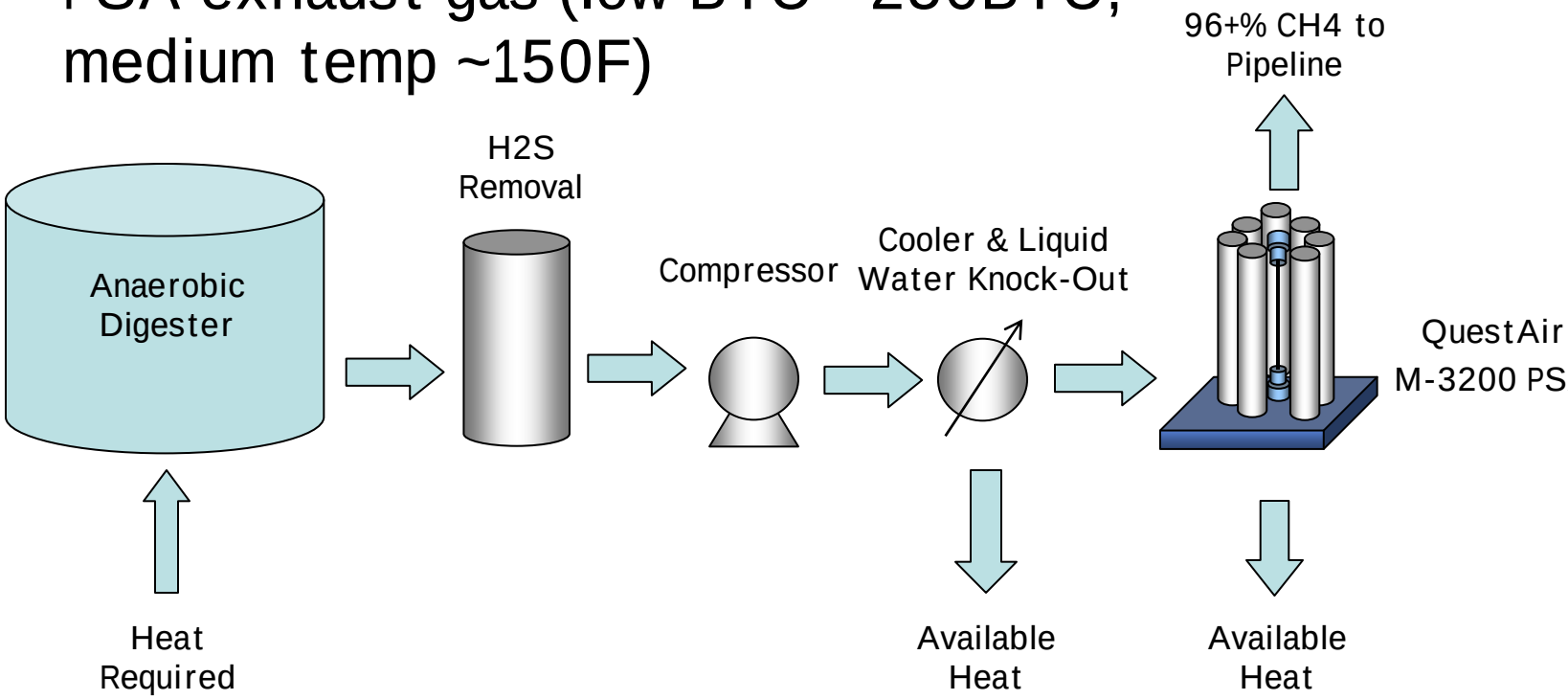
UPGRADING

(PSA, WATER SCRUBBED, AMINE, MEMBRANE)

ODORIZATION & INSERTION

WASTE HEAT AVAILABILITY

- Biogas to boiler
- Compressor heat exchanger
- PSA exhaust gas (low BTU ~250BTU, medium temp ~150F)

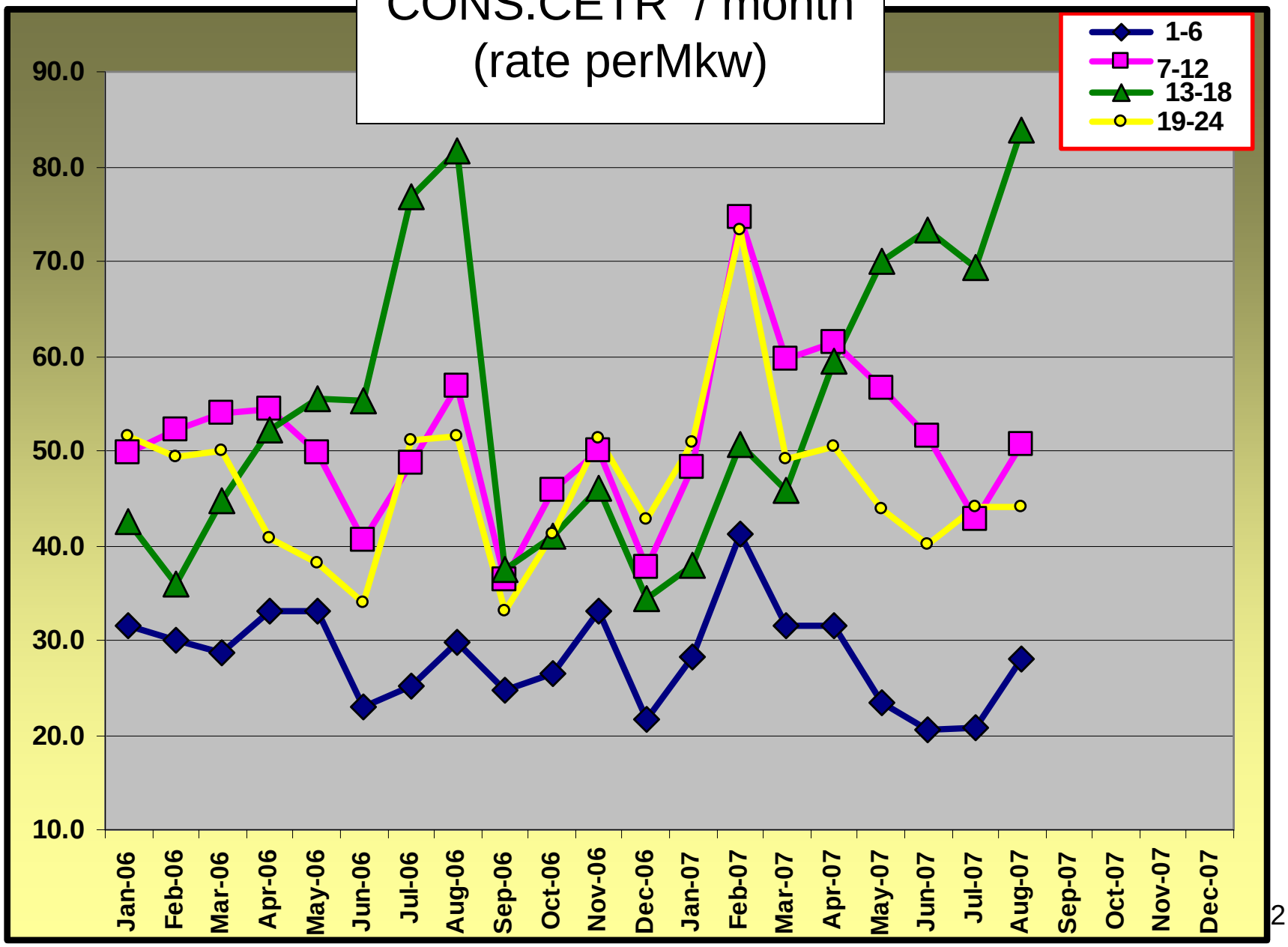


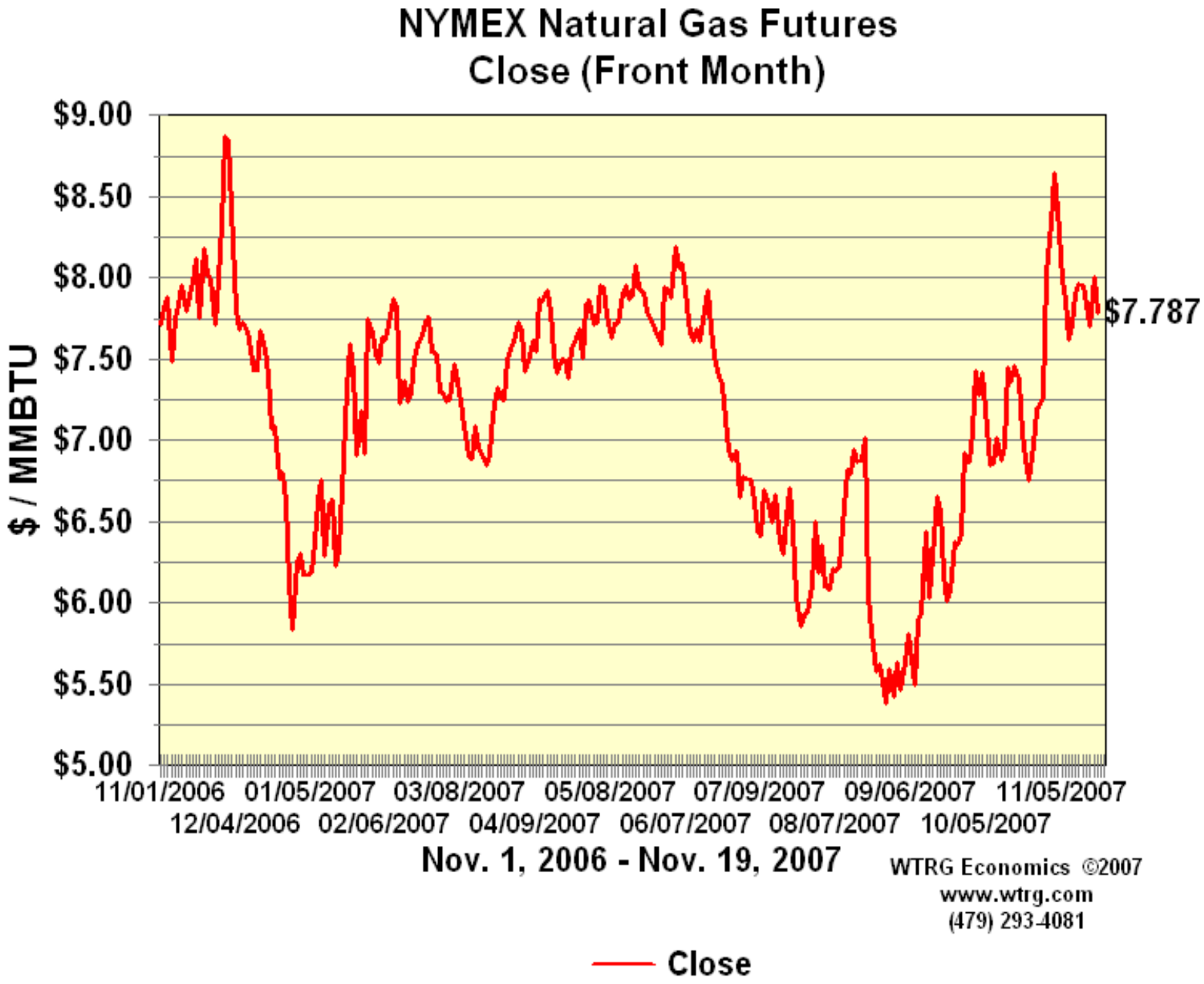
POTENTIAL ENERGY PRODUCTION FROM 1000-COW DAIRY

Assumed Total Solid %'s	8.0%
Co-feed - Gallons	0

	18d	24d	28d
Biogas Production per year - cft	70,080,000	76,650,000	78,840,000
Biogas Flowrate - cft / minute	133	146	150
cft of methane per year	38,544,000	45,990,000	48,880,800
MMBTU's per year (millions)	38,852	46,358	49,272
MMBTU's per hour	4.4	5.3	5.6
CFT CH4 PER DAY	105,600	126,000	133,920
Farm usage only MMBTU's factored for conversion efficiency 14,640			
Farm Usage % of Energy generated	38%	32%	30%
Energy generated % of farm usaage	265%	317%	337%

LMP avg price - CONS.CETR / month (rate perMkw)




NYMEX Natural Gas Futures
Close (Front Month)
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$8.00
$7.50
$7.00
$6.50
$6.00
$5.50
$5.00
$ / MMBTU
$7.787
11/01/2006
12/04/2006
01/05/2007
02/06/2007
03/08/2007
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Nov. 1, 2006 - Nov. 19, 2007
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COMPARITIVE ECONOMICS

PROJECT FINANCIAL ASSESSMENT
SAMPLE - 2000 cow dairy

INITIATIVE

21,900,000 Total gallons of manure per year
46,358 MM BTU/yr

ENERGY SALES

39,092 Total volume (1000 cft) of Natural Gas available for Pipeline / year
$293,186 Potential Natural Gas Revenue Stream / year

Price Range - Natgas price/1000cft				Revenue Range / year		
Low	Modeled	High		Low	Modeled	High
$4.000	$7.500	$10.000		$156,366	$293,186	$390,915
			$/MM BTU	$3.37	$6.32	$8.43

OR

5,162,957 Total volume (kWh) of Electricity Production / year
$258,148 Potential Electricity Revenue Stream / year

Price Range - Elec price/kWh				Revenue Range / year		
Low	Modeled	High		Low	Modeled	High
$0.030	$0.050	$0.060		$154,889	$258,148	$309,777
			$/MM BTU	$3.34	$5.57	$6.68

COMPARITIVE O&M COSTS

BIGGEST SWING FACTORS:

- H2S level in biogas and cost of removal - Range from 500 ppm to 2500 ppm, $1.50 to $5.00 per pound of sulfur removed
- Type and number of compressors and insertion pressure - Single or Two stage, rotary lobe or single screw, 60 psig to 750 psig
- Up-time availability assumptions for gensets vs. Gas Upgrading system - 45% to 96%
- Purchasing or Producing electricity for Gas Upgrading system - Self-generation at selling price or Purchase from grid at retail
- Variable Load Efficiency Impact - 5-25% Conversion Efficiency Impact

FIRST COMBINATION ON-FARM RENEWABLE ENERGY PRODUCTION FACILITY

SCENIC VIEW DAIRY

FENNVILLE, MI

FEED GAS: UP TO 150 CFM

PRODUCT GAS: ~75 CFM

INSERTION PRESSURE: 120-150 PSIG

FIRST COMBINATION ON-FARM RENEWABLE ENERGY PRODUCTION FACILITY

SCENIC VIEW DAIRY

FENNVILLE, MI

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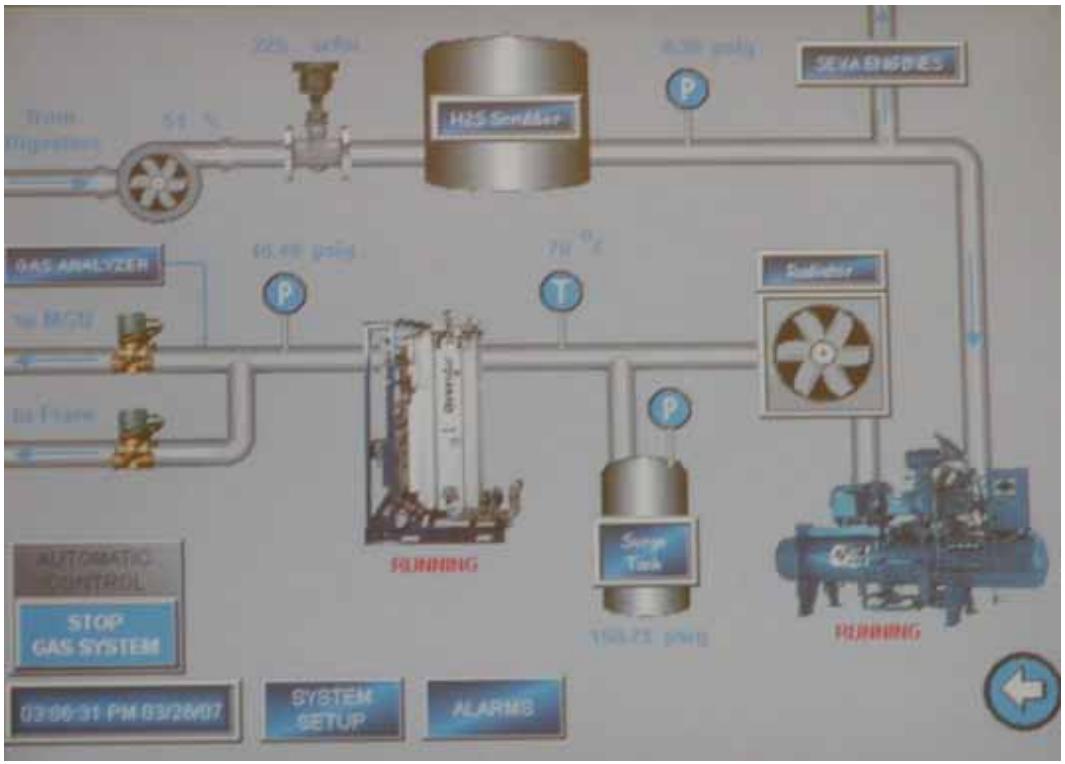

FEEDSTOCK OPTIONS TO INCREASE BIOGAS PRODUCTION

GLYCERINE

PHASE 3
RENEWABLES

QUESTIONS?

THANK YOU!

Norma McDonald * Sean Mezei

QuestAir